

CLAIMS

What is claimed is:

- 1 1. A sensor node comprising at least one substrate coupled among at least
2 one processor and at least one energy source, wherein the at least one substrate
3 is at least one sensor, wherein functions of the sensor node are remotely
4 controllable and the sensor node is programmable via wireless internetworking
5 among a plurality of network elements.
- 1 2. The sensor node of claim 1, wherein the at least one substrate comprises
2 active and passive substrates.
- 1 3. The sensor node of claim 2, wherein the at least one substrate comprises
2 at least one thin film substrate, wherein the at least one thin film substrate
3 comprises a piezoelectric polymer film, wherein the piezoelectric polymer film
4 is polyvinylidenedifluoride (PVF₂).
- 1 4. The sensor node of claim 1, wherein the at least one substrate is
2 conformal.
- 1 5. The sensor node of claim 1, further comprising at least one device
2 selected from a group consisting of at least one preprocessor, at least one
3 interface, at least one application programming interface (API), at least one
4 antenna, and at least one transmitter.
- 1 6. The sensor node of claim 5, wherein the at least one antenna includes a
2 dielectric ring antenna.

1 7. The sensor node of claim 5, wherein the at least one interface includes at
2 least one communication interface supporting at least one communication mode
3 selected from a group consisting of wireless communications, wired
4 communications, and hybrid wired and wireless communications.

1 8. The sensor node of claim 1, further comprising at least one state
2 machine controlling at least one function selected from a group consisting of
3 sensing, signal processing, data processing, event recognition, communication,
4 power management, and network assembly.

1 9. The sensor node of claim 1, further comprising at least one
2 communication physical layer including radio frequency (RF) power
3 management.

1 10. The sensor node of claim 1, wherein the at least one processor is coupled
2 to at least one component selected from a group consisting of actuators, sensors,
3 signal processors, interfaces, power supplies, data storage devices, and
4 communication devices.

1 11. The sensor node of claim 1, wherein the at least one sensor comprises at
2 least one sensor selected from a group consisting of passive and active sensors,
3 wherein the passive and active sensors include seismic sensors, acoustic
4 sensors, optical sensors, infrared sensors, magnetic sensors, thermal sensors,
5 accelerometers, and bi-static sensors.

- 1 12. The sensor node of claim 1, wherein the at least one energy source
2 includes a thin film photovoltaic device, wherein the thin film photovoltaic
3 device is an energy source and an optical presence detection sensor.
- 1 13. The sensor node of claim 1, wherein the sensor node is coupled to at
2 least one item selected from a group consisting of machinery components,
3 electronic equipment, mechanical equipment, electro-mechanical equipment, a
4 facility, a structure, a material, a biological system, people, animals, vegetation,
5 clothing, crates, packages, product containers, shipping containers, a
6 transportation system, vehicle components, an outdoor area, and an indoor area.
- 1 14. The sensor node of claim 1, wherein the at least one sensor receives at
2 least one signal type selected from a group consisting of temperature, shock,
3 vibration, motion, acceleration, tip, light, sound, and package opening and
4 closing.
- 1 15. The sensor node of claim 1, wherein the plurality of network elements
2 comprise a sensor network including at least one element selected from a group
3 consisting of at least one node, at least one gateway, at least one server, at least
4 one network, at least one client computer hosting a World Wide Web browser,
5 at least one interrogator, and at least one repeater.
- 1 16. The sensor node of claim 15, wherein the at least one node is coupled
2 among a monitored environment and at least one client computer, wherein
3 functions of the at least one node are remotely controllable using the at least one
4 client computer, wherein the at least one node provides node information

5 including node resource cost and message priority to the plurality of network
6 elements, wherein data processing is distributed through the sensor network in
7 response to the node information.

1 17. The sensor node of claim 15, wherein the at least one node includes
2 sensing, processing, communications, and storage devices supporting a plurality
3 of processing and protocol layers.

1 18. The sensor node of claim 15, wherein the sensor node is coupled to the
2 at least one client computer through the plurality of network elements, wherein
3 the at least one node supports at least one communication mode selected from a
4 group consisting of wireless communications, wired communications, and
5 hybrid wired and wireless communications, wherein at least one redundant
6 communication pathway is established among the plurality of network elements.

1 19. The sensor node of claim 15, wherein the at least one gateway performs
2 at least one function selected from a group consisting of protocol translation,
3 sensor network management, management of transmissions from a remote user,
4 and interfacing with at least one communication physical layer including wired
5 local area network, packet radio, microwave, optical, wireline telephony,
6 cellular telephony, and satellite telephony.

1 20. The sensor node of claim 15, wherein the at least one network includes
2 wired networks, wireless networks, and hybrid wired and wireless networks,
3 wherein the at least one network comprises at least one network selected from a

4 group comprising the Internet, local area networks, wide area networks,
5 metropolitan area networks, and information service stations.

1 21. The sensor node of claim 1, wherein the internetworking comprises
2 providing remote accessibility using World Wide Web-based tools to data,
3 code, management, and security functions, wherein data includes signals and
4 images, wherein code includes signal processing, decision support, and database
5 elements, and wherein management includes operation of the plurality of
6 network elements.

1 22. The sensor node of claim 15, wherein the plurality of network elements
2 comprise a plurality of network element sets that are layered.

1 23. The sensor node of claim 15, wherein the at least one node comprises a
2 plurality of node types, wherein the plurality of node types includes at least one
3 node of a first type and at least one node of a second type, wherein a first
4 network having a first node density is assembled using the at least one node of a
5 first type, wherein a second network having a second node density is assembled
6 using the at least one node of a second type, wherein the second network is
7 overlaid onto the first network.

1 24. The sensor node of claim 15, wherein code and data anticipated for
2 future use are predistributed through the sensor network using low priority
3 messages, wherein the code and the data are downloadable from at least one
4 location selected from a group consisting of storage devices of the plurality of
5 network elements, and storage devices outside the sensor network.

1 25. The sensor node of claim 16, wherein the plurality of network elements
2 automatically organize in response to the node information, wherein the
3 automatic organizing comprises automatically controlling data transfer,
4 processing, and storage within the network.

1 26. The sensor node of claim 15, wherein a plurality of levels of
2 synchronization are supported among different subsets of the plurality of
3 network elements, wherein a first level of synchronization is supported among a
4 first subset of the plurality of network elements, wherein a second level of
5 synchronization is supported among a second subset of the plurality of network
6 elements.

1 27. The sensor node of claim 1, wherein data processing is controlled using
2 at least one processing hierarchy, the at least one processing hierarchy
3 controlling at least one event selected from a group consisting of data
4 classifications, data transfers, data queing, data combining, processing
5 locations, communications among the plurality of network elements.

1 28. The sensor node of claim 1, wherein data is transferred using message
2 packets, wherein the message packets are aggregated into compact forms in the
3 plurality of network elements using message aggregation protocols, wherein the
4 message aggregation protocols are adaptive to data type, node density, message
5 priority, and available energy.

1 29. The sensor node of claim 15, wherein the functions of the at least one
2 node include data acquisition, data processing, communication, data routing,
3 data security, programming, and node operation.

1 30. The sensor node of claim 15, wherein the at least one node includes at
2 least one processor coupled to a plurality of application programming interfaces
3 (APIs), wherein the plurality of APIs are coupled to control the sensor node and
4 at least one device selected from a group consisting of sensors, actuators,
5 communications devices, signal processors, information storage devices, node
6 controllers, and power supply devices, wherein the plurality of APIs support
7 remote reprogramming and control of the at least one device, wherein the
8 plurality of APIs are layered.

1 31. The sensor node of claim 30, wherein the plurality of APIs enable
2 distributed resource management by providing network resource information
3 and message priority information to the plurality of network elements, wherein
4 information transfer among the plurality of network elements is controlled using
5 a synchronism hierarchy established in response to the resource information and
6 message priority information.

1 32. The sensor node of claim 15, wherein the at least one node controls data
2 processing and data transmission in response to a probability of a detected
3 event.

1 33. The sensor node of claim 15, wherein the plurality of network elements
2 are self-assembling, wherein search and acquisition modes of the at least one

3 node search for participating ones of the plurality of network elements, wherein
4 a determination is made whether each of the participating ones of the plurality
5 of network elements are permitted to join the sensor network using a message
6 hierarchy, wherein the sensor network is surveyed at random intervals for new
7 nodes and missing nodes.

1 34. The sensor node of claim 15, wherein the plurality of network elements
2 further include at least one database, wherein the at least one database includes
3 at least one storage device selected from a group consisting of storage devices
4 coupled to at least one of the plurality of network elements and storage devices
5 of the at least one node, wherein the at least one database comprises data-driven
6 alerting methods that recognize conditions on user-defined data relationships
7 including coincidence in signal arrival, node power status, and network
8 communication status.

1 35. The sensor node of claim 15, wherein data is collected from the sensor
2 node by the at least one node, wherein at least one operation is performed on the
3 data in response to parameters established by a user, the at least one operation
4 selected from a group consisting of energy detection, routing, processing,
5 storing, and fusing, wherein the routing, processing, storing, and fusing are
6 performed in response to at least one result of the energy detection.

1 36. The sensor node of claim 34, wherein the routing comprises selecting at
2 least one data type for routing, selecting at least one of the plurality of network
3 elements to which to route the selected data, selecting at least one route to the
4 selected at least one of the plurality of network elements, and routing the
5 selected at least one data type to the selected at least one of the plurality of
6 network elements.

7 37. The sensor node of claim 34, wherein the processing comprises selecting
8 at least one data type for processing, selecting at least one processing type,
9 selecting at least one of the plurality of network elements to perform the
10 selected at least one processing type, and transferring the selected at least one
11 data type to the selected at least one of the plurality of network elements using
12 at least one route through the sensor network, wherein the selection of at least
13 one processing type comprises determining at least one probability associated
14 with a detected event and selecting at least one processing type in response to
15 the at least one probability.

1 38. The sensor node of claim 34, wherein the storing comprises selecting at
2 least one data type for storage, selecting at least one storage type, selecting at
3 least one of the plurality of network elements to perform the selected at least
4 one storage type, and transferring the selected at least one data type to the
5 selected at least one of the plurality of network elements using at least one route
6 through the sensor network.

1 40. The sensor node of claim 1, wherein at least one of the plurality of
2 network elements determines a position of the sensor node.

1 41. The sensor node of claim 1, wherein the sensor node determines at least
2 one position using location information received from at least one of the
3 plurality of network elements.

1 42. The sensor node of claim 1, wherein data is collected by the at least one
2 sensor, wherein at least one operation is performed on the data in response to
3 parameters established by a user, the at least one operation selected from a
4 group consisting of aggregating the data with data collected from other sensor
5 nodes, energy detection, routing, processing, storing, and fusing.

1 43. The sensor node of claim 1, wherein the at least one substrate comprises
2 a thin film tape, wherein the thin film tape includes an adhesive.

1 44. A sensor node comprising at least one substrate means coupled among a
2 means for processing and a means for providing power, wherein the at least one
3 substrate means is a means for sensing, wherein functions of the sensor node are
4 remotely controllable and the sensor node is programmable via a means for
5 wireless internetworking.